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EXTENDED SHELF LIFE OF PRECOOKED MEALS

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Naticks, Massachusetts

June 1974

EXTENDED SHELF LIFE OF PRECOOKED-REFRIGERATED MEALS

by

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Many of the references were translated from Swedish publications not readily available in the United States of America. Copies of all references with translations are attached to the file copy of this report.

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Meals	Microbiological deterioration	Precooked meals
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The state-of-the-art was surveyed to determine whether a food system based on refrigerated storage up to 30 days was technically achievable. Based on European experience especially the so-called NACKA system in Sweden and consideration of the microbiological and public health aspects it is clear that such a system is feasible if refrigeration temperature is held at about 30-36°F. (1.1 to 4.4°C).

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Item 20 (continued):

No data showing a quality advantage for refrigerated over frozen storage were found. Limited experiments with several entrees and vegetables showed the quality after 30 days storage at refrigerated temperatures of 28-32°F.(2.2 to -0°C) to be comparable to those held frozen at 0°F.(17.8°C), except for one meat item and two vegetables where the frozen stored were preferred. No data were found and no experiments were conducted on items which do not freeze well.

Except for special situations the application of a refrigerated food service system is not recommended.

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TECHNICAL REPORT
75-15-FEL

EXTENDED SHELF LIFE OF PRECOOKED REFRIGERATED MEALS

By: C. K. WADSWORTH

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FOREWORD

This report is in response to an Air Force requirement to develop technology for extending to a minimum of 30 days the effective storage shelf life of precooked refrigerated meals. As first stated, such meals were needed for use where freezer facilities are unavailable or limited, e.g., remote sites, in-flight, aero-medical evacuation and certain contingency situations. Subsequently, it was suggested that technology for extending shelf life of selected items rather than a complete meal may be useful. There was an expectation that refrigerated storage as an alternative to frozen storage would improve quality and permit the use of items which do not withstand freezing well or at all.

This work was performed under Project Number 1J762713A034, Military Food Service and Subsistence Technology and 1J161102A71C, Food and Food Service Research; Service Requirement Identification Code AF-3-13.

ABSTRACT

The state-of-the art was surveyed to determine whether a food system based on refrigerated storage up to 30 days was technically achievable. Based on European experience especially the so-called Nacka system in Sweden and consideration of the microbiological and public health aspects it is clear that such a system is feasible if refrigeration temperatures are held at about 30 to 36°F. (-1.1 to 2.2°C) rather than the normal 34 to 40°F. (1.1 to 4.4°C).

No data showing a quality advantage for refrigerated over frozen storage were found. Limited experiments with several entrees and vegetables showed the quality after 30 days storage at refrigerated temperatures of 28 to 32°F.(-2.2 to 0°C) to be comparable to those held frozen at 0°F. (-17.8°C) except for one meat item and two vegetables where the frozen stored were preferred. No data were found and no experiments were conducted on items which do not freeze well.

Except for special situations the application of a food service system requiring 30 days refrigerated storage is not recommended.

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INTRODUCTION

When the Air Force requirement involving refrigerated storage of precooked meals for a period of 30 days was discussed, there were misgivings as to whether the requirement was technically achievable.

It was known that food service systems involving extended refrigerated storage had been developed in Sweden and elsewhere in Europe. Work was in progress at NLABS in connection with the studies on food service systems which offered a convenient framework for considering the extension of refrigerated storage.

Accordingly, it was agreed that as first steps NLABS would survey the state-of-the-art and undertake a limited exploratory effort. The results are reported below.

BACKGROUND

1. Microbiological aspects.

Microbiological considerations override all others and are therefore considered first. There are two aspects, public health or safety, and spoilage. Both of these are so dependent upon storage temperature that a few statements regarding refrigeration temperature are included here. "Normal" refrigeration temperature is difficult to define, but apparently is accepted to cover the range of 34 to 40°F. (1.1 to 4.4°C). The 30-day storage of precooked meals at "normal" refrigeration temperatures would be neither safe nor adequate to prevent spoilage. Thus, consideration must be given to "super" refrigeration. To provide some minimum of variation in temperature control it will be considered that "super" refrigeration means 30 to 36°F. (-1.1 to 2.2°C).

To provide an idea of refrigerator performance, recorders were placed in several refrigerators containing normal loads and the temperature determined over a period of 24 hours or more. Results were as follows:

	Approx. set point °F	(°C)	Variation at one point °F	(°C)	Point to point var. (approx.) °F	(°C)
Domestic type	37.5	(3.1)	± 2.5	(± 1.4)	2	(1.1)
Installed 40 cu. ft.	33	(0.6)	± 7	(± 3.9)	3	(1.7)
Installed 100 cu.ft.						
Day	36	(2.2)	± 5	(± 2.8)	4	(2.2)
Night	36	(2.2)	± 3	(± 1.7)	2	(1.1)
Army 70 cu.ft. Modified to improve distribution	31	(-0.6)	± 1	(± 0.6)	<1	(0.6)

We were able to modify a standard Army 70 cu. ft. refrigerator and maintain consistently low temperatures over periods of several weeks. This very emphatically does not indicate that the performance could be repeated with dozens of refrigerators over a long period. However, the development and/or modification of equipment to assure reliable performance should be possible.

2. Public health aspects

The three genera of bacteria of greatest importance are Clostridium, Staphylococcus and Salmonella. The first two produce exotoxins, the third, infection. Voluminous data are available on all. Michener and Elliott (1) have made a comprehensive review. A National Academy of Sciences - National Research Council report (2) gives an excellent summary and evaluation of hazards.

Fuller treatment of the effect of temperature on the growth of Clostridium botulinum Type E is given in the publications of Schmidt et al. (3) and Abrahamsson et al. (4). Many investigators have studied the effect of temperature on Staphylococcus and Salmonella and the relationship to growth and food poisoning. These include Angelotti et al. (5) Miller and Smull (6) and Kelly and Dack (7).

The following summary based on (1) and (2) is given below:

	Minimum Temperatures for growth °F.	(°C)
Cl. botulinum Types A, B and C	50	10
Cl. botulinum Type E	38	3.3
Staphylococcus	44	6.7
Salmonella	44	6.7

Clostridium perfringens(not included above) grows very slowly below 68°F. (20°C).

Clostridium botulinum Types A, B and C do not grow below 50°F.(10°C). Staphylococcus and Salmonella do not grow below 44°F.(6.8°C).

Clostridium botulinum Type E, which grows at the lowest temperatures of all required with massive inoculations 14 to 21 days to show growth and toxin production at 38°F.(3.3°C). There was no growth or toxin at 36°F.(2.2°C) after 104 days.

There is no known reason to question the safety from a microbiological standpoint of properly handled food held at temperatures at or below 36°F. (2.2°C) for 30 days. A case could perhaps be made for the safety of storing for 30 days at a somewhat higher temperature but only if accompanied by very stringent controls.

3. Spoilage.

Refrigeration as discussed above will essentially prevent the growth of mesophilic microorganisms. However, yeasts, molds and psychrophilic bacteria grow at temperatures as low as 14°F. (-10°C). A sampling of the extensive literature on psychrophilic microorganisms is shown in references (8-12). Especially valuable are the reviews by Elliott and Michener (11) and Witter (12). There are several approaches to preventing the growth of psychrophilic microorganisms. One is to reduce the numbers present by raw material selection, control and appropriate sanitation. Most are killed by relatively mild heat treatment and thus destroyed by cooking. Psychrophiles are predominantly aerobic; so packaging which excludes oxygen can be helpful. In all cases lower temperatures slow the rate of growth. Thus, while an ever present threat, psychrophilic spoilage is preventable.

The Nacka hospital in Sweden and several other institutions which have developed refrigerated food systems have gone to extreme lengths with microbiological analyses. Unquestionably any process involving preservation of food must have strict and thorough microbiological control. However, there appears to have been a tendency to emphasize microbiological analyses at the expense of controlling the manufacturing operations.

In any future consideration of extended refrigerated storage, management should insist on properly balancing the attention given to raw material selection and observance of specified times and temperatures during processing and storage. Fewer microbiological analyses will be required and they will have more meaning.

4. Food acceptance.

Data comparing frozen prepared vs. refrigerated prepared meals are not readily available. The little which was found is listed below:

	Product	Evaluation on a 9-point scale: Frozen 0°F. (-17.8°C)	Refrigerated 40°F. (4.4°C)	Reference
a.	Ave 30 meat items stored 1 day - Tech evaluation	6.7	6.8	(13)
b.	Ave 10 menus frozen foil pack meals by 4 AF man (stored - 6 months)	6.8	Not included	(14)
c.	Ave 8997 refrigerated foil pack meals by flight crews	N/A	7.2	(15)
d.	Ave 9 meat items in 11,696 precooked frozen meals	6.9	N/A	(16)

The data show that both refrigerated and frozen meals and/or components are acceptable. No advantage for refrigerated storage was observed. No information was found encompassing foods which do not respond well to freezing.

EXPERIENCE OF OTHERS

Two systems based on refrigerated storage of precooked foods are discussed below. Published information is limited. Some of it is repetitious and contains elements of bias.

1. Nacka system (17, 18, 19).

a. General

The key points concerned are shown in outline form as follows:

(1) Number of products - 150 ±.

(2) Type - entrees and vegetables.

(3) Preparation - normal cooking.

(4) Packaging - 5 portions in plastic bags.

(5) Pasteurization - boiling water for about 3 mins then water cooled.

(6) Storage - Temp. - 37°F.(3°C).
Time - Up to 3 weeks.

(7) Preparation for service- boiling water 25-30 minutes.

This system was developed in 1958 for use in Swedish mines. It was adopted by the city of Stockholm in 1966 with production in the Nacka Hospital serving (in 1968) some 25 different institutions. There was fairly substantial production over an extended period amounting to 12,000 portions per day at Nacka and another 20,000 portions per day at a new plant in Malmberget. In 1970, there were produced 3,557,679 servings distributed to 36 hospitals cafeteria and schools.

b. Quality

The organoleptic quality is undeterminable. Objective data have not been found, but it seems reasonable to expect that there were wide variations. To quote from the developer, Delphin(20): "The organoleptic investigations --- of the one hundred dishes revealed --- they can well hold their own --- with conventionally prepared food". Palm (21) states, "The method gives in the opinion of many persons a dubious result from the culinary and organoleptic viewpoint." In a comparative study (22) of conventional kitchen technique, the Nacka system and precooked frozen foods carried out at two different hospitals frozen foods were found to be better in quality than the products of the other systems.

In spite of inadequate and conflicting data the incontrovertible fact remains that over a period of several years many millions of meal portions following the Nacka system have been produced and eaten. Thus, the quality overall must have been at least minimally satisfactory. The criticism may be in part due to limitations of the system in that the method is simply not the preferred way of handling some foods and thus their quality is bound to be low. Quality control seems to have been a substantial problem and this, of course, could have led to substandard quality.

c. Nutritional aspects.

Delphin (20) advises that the menus were based on the standards established by the Food and Nutrition Board in Washington, D.C. in 1958 and amendments. The system comprises one nutritive schedule for normal food and one for dietary food. The normal diet for patients in hospitals is on the average 2,200 calories per day with 100 g. protein, 80 g. fat and 250 g. carbohydrates with approximately 3,000 IE Vitamin A, 1.8 mg. B_1, 2.5 mg. B_2, 18 mg. B_3, 150 mg. C, 17 mg. F_e and 1,000 mg. C_a.

He reports that a study of the effects of storage and preparation, by a group of experts in 1966-1967 showed:

(1) No significant changes in protein value or composition of fatty acids.

(2) No changes in Vitamin A, thiamine, riboflavin, nicotinic acid, panthothenic acid or salts.

(3) Content of ascorbic acid in liquid food is fairly heavily reduced.

d. Bacteriological hygiene.

Per Delphin (20): Cultures have been taken from each batch of food prepared, both on the day cooked and when taken out of storage. Over a period of 10 years covering 16 million portions of food, and 50,000 bacteriological tests products have been entirely satisfactory. According to the Swedish National Veterinary Board opinion the method satisfies the highest demands on hygiene.

e. Packaging.

The film used was Rikam, polyamide. The food was packed, usually hot, usually in 5 portions. Air was ejected and the packages sealed manually with a metal clip and the end sealed with an open flame.

f. Staffing

Staff of 13 including a full time bacteriologist prepared an average daily production of 7,500 portions.

g. Cost

A study by the Business Research Institute of the Stockholm School of Economics prior to 1968 of the cost effects of changing from conventional de-centralized food production to the Nacka system and recalculated by Delphin(20) to a production rate of 10,000 portions per day showed a net reduction of $210,000 per year equivalent to a savings of 28%. The reductions were largely due to smaller capital costs($108,000 less),reduced staff($144,000 less) and supervision and quality control ($43,000 more). As previously noted the Nacka system is involved in only about 25% of the total food. Thus as a percentage of the total food service cost the savings would be about 7% (25% of 28%). Actual cost data are not available but based on the above there is no indication of dramatic savings.

Bengtsson(22) in 1972 covered a study of three food systems; conventional, frozen and chilled (Nacka). The daily serving costs in kroner were respectively 14.54, 14.26 and 15.58. On the basis of this study the recommendation was made to develop a mixed system based chiefly on frozen industrial products.

h. Status

The Nacka system in Sweden has been discontinued. The date is not known, but on the basis of a personal communication (23) from SIK and Trip Report (21) of Byrne and Tuomy it was prior to 15 March 1973.

2. Extensions of the Nacka system.

There have been applications in Germany, Holland and Switzerland as well as in Sweden. That in Switzerland at least is still in operation. Some information regarding these has been obtained (24, 25, 26, 27). Much of this is repetitious and concerns variations of the Nacka system. A development in the United States is discussed below.

a. The AGS system

(1) Description

This covered a three-year study (28) of three South Carolina hospitals (Anderson, Greenville, Spartansburg-AGS) with the food produced in one hospital for use in all three. The keypoints in outline form follow.

(a) Number of products - see (b).

(b) Type - all entrees and vegetables for lunch and supper including special diets.

(c) Preparation - various degrees of doneness, some raw.

(d) Packing - vacuum-packaged in 1 to 5 portions.

(e) Pasteurization and cooking - variable in hot water bath, chilled in ice water.

(f) Storage: Temp.- 28-32°F.(-2.2 to 0°C).
Time - Up to 60 days.

(g) Preparation for service - hot water bath 30-40 mins to reach internal temperature of 160°F.(71°C), plated then heated 10-20 seconds in microwave oven just prior to serving (optional-plastic film over dish).

(2) Status (29).

At the end of the above 3-year period a small factory was built and a 6-month test conducted by supplying a small satellite hospital. The results appeared satisfactory to all concerned and as the next step arrangements were made to supply the large Greenville General Hospital.

It had supposedly been made clear during meetings with the hospital management that food costs would be somewhat higher and that this must be off-set by reductions in staff at the hospital. The hospital participated for two weeks without reducing staff and then abruptly cancelled future order purportedly due to high costs.

Further details are covered in references. A lesson to be learned here is that a new food service system involves many factors beyond the technical ones. There were many points in the AGS system which would be of interest if a refrigerated system were to be developed.

EXPERIMENTAL

In view of the lack of direct comparative data on prepared food stored frozen and under refrigeration a limited number of experiments have been conducted here. Detailed results are shown in the Appendix.

Several entrees and vegetables were prepared and distributed in half steam table trays (5 lbs per tray). A portion of each was chilled and another portion frozen. The chilled samples were held at 30 to 32°F (-1.1 to 0°C) and the frozen samples were held at 0°F.(-19°C) for 30 days and then tested.

In three cases out of eight there were significant preferences for samples held in frozen storage over those held in refrigerated storage. The data are not sufficient to support a general conclusion. However, in view of these results further comparative tests did not seem justified. Somewhat corollary studies have been carried out on another project in which frozen foods were stored in insulated containers and allowed to thaw out over a period of 3 to 4 weeks. The work was not considered sufficiently

pertinent to report here but in general the results in terms of product quality and microbiology were similar to those with non-frozen products held near 32°F.(0°C) for the same period.

DISCUSSION

1. Technically, a system of food services based on refrigerated storage of prepared entrees and vegetables for up to 30 days appears feasible. The microbiological considerations are well understood and the extensive experience of Nacka and counterparts show beyond question that such a system is possible.

2. There are two factors to be considered:

a. There are claims, which perhaps could be substantiated, of modest advantages in quality of a few items, savings in refrigeration cost vs. frozen storage and elimination of the steps of freezing and thawing. There might be somewhat greater convenience in using refrigerated products. However, over a broad range of products there appear to be no solid advantages.

b. In contrast to frozen storage which provides a substantial margin for abuse, refrigerated storage leaves virtually no margin. Accordingly, success would require a mangement and operational perfection which traditionally has not been applied in food service operations.

RECOMMENDATIONS

1. For general application a refrigeration food system is not recommended.

2. If there are special situations which justify its application and if the management concerned is willing to pay the price in vigilance and cost, there are no technical obstacles to prevent development and application of a refrigerated food system.

FUTURE WORK

If it is decided to give further consideration to a refrigerated food system, the following sequence of steps is suggested as a starting point:

a. Select specific foods of interest and outline tentative plans for use.

b. Establish whether there are significant benefits vs. fresh or frozen with regard to acceptance, cost, state of readiness, etc.

c. If indicated, proceed with the following:

(1) Develop specific procedures for production, quality assurance and preparation.

(2) Develop or assure the availability of "super" refrigeration equipment.

(3) Prove out equipment and establish proper safeguards, instrumentation and alarm system.

(4) Test through field tests.

(5) Recommend management requirements and placement of responsibilities.

(6) Provide operation requirements.

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STSNL-FPD 24 September 1973

MEMO FOR RECORD

SUBJECT: Refrigeration of Prepared Food Items at 28-32°F.

1. Four separate tests were conducted on prepared food items stored for 30 days at 28-32°F. The food items were prepared and distributed in half steam table trays (5 lbs per tray of entree items; 4 lbs per tray of vegetable items). The recipes for the entree items were those used in the Fort Lee Central Food Preparation Facility. Tests I and II compared the microbiology of samples stored at 28-32°F. to samples stored at 35-40°F.

2. The following table shows the microbiology test results of the first and second tests:

Microbiology Test Results* for Test I and II

Product	Initial	10 days	17 days	24 days	30 days
Creamed Beef(I)					
28-32°F.	<30	20	10	10	<10
35-40°F.	<30	10	10	15	<10
Creamed Pork(II)					
28-32°F.	750	790	825	910	1200
35-40°F.	780	645	800	860	1100

*These results are for aerobic plate counts per gram, incubated 48 hrs at 95°F.(35°C).

3. Acceptance tests by 36 panelists were conducted on two items: Creamed Beef and Chicken a la King. The items were tested on the 30-day after storage began. The items were tempered at 40°F. to bring the frozen and refrigerated sample to equal temperatures for equal cooking time. No significant preference was found.

Acceptance Test Results* for Test Group III

Product	Experimental sample mean rating (28-32°F)	Control sample mean rating (0°F)
Creamed Beef	6.6 ± 1.4	6.5 ± 1.7
Chicken a la King	7.4 ± 1.1	7.2 ± 1.4

*The Hedonic rating system from 1 to 9 was used; 9= highest rating, 5= average and 1 = lowest rating.

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4. Acceptance tests were conducted on five entree items and three vegetables. The test on the entrees were conducted by 32 panelists; the test on the vegetables were conducted by 36 panelists. A significant preference was found on two of the vegetables and one of the entree items.

Acceptance Test Results for Test Group IV

Product	Experimental sample mean rating (28-32°F.)	Control sample mean rating (0°F.)
Breaded Pork Slices*	6.7 ± 1.4	7.2 ± 1.3
Meatloaf w/Gravy	6.8 ± 1.3	6.8 ± 1.3
Salmon Cakes	7.0 ± 1.4	7.0 ± 1.4
Roast Beef w/Gravy	6.8 ± 1.6	7.3 ± 1.6
Roast Turkey w/Gravy	6.4 ± 1.3	6.6 ± 1.5
Green Peas	6.2 ± 1.7	6.6 ± 1.5
Whole Kernel Corn*	5.1 ± 1.7	5.6 ± 1.7
Green Beans*	5.7 ± 2.0	6.3 ± 1.2

*Control sample significantly preferred to experimental.

5. From the above after 30 days storage at 28-32°F, all entrees tested were acceptable. Seven of eight refrigerated entrees were equal to frozen controls; none was superior. In the case of Breaded Pork Slices the control was significantly preferred. Two or three refrigerated vegetables were significantly inferior to frozen controls. This may be due at least in part, to overheating during processing and/or preparation. Tests of the corn and beans are being repeated.

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